Rear-end Collision Prevention Using Mobile Devices

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DSP in vehicle 2013

Introduction

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- 29% of the crashes are rear-end collisions
- State-of-the-art ADASs are only available in luxury cars
- Mobile devices are used within vehicular environment

- Goal: Use the built-in camera of commercial portable devices to detect frontal vehicle for preventing rear-end collisions

Frontal Vehicle Detection and Distance Estimation

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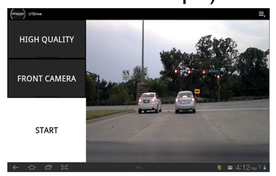
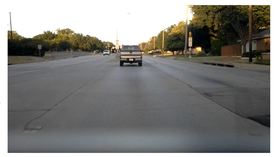
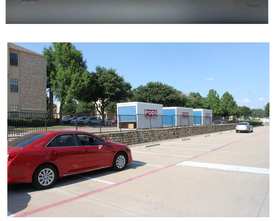
- Device: Samsung Galaxy Tab10.1WiFi (1280x720 at 30 fps)

- Naturalistic Driving Data
  - One car, over 30 hours
  - Various weather and road conditions





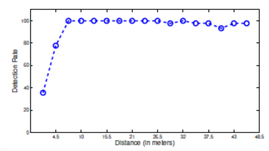


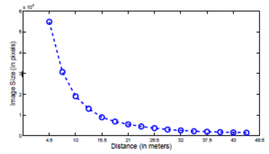
- Controlled Data
  - 3 cars, 2 are used each time
  - Tablet mounted on ego vehicle
  - Second vehicle moving in front
  - Known distance between cars

- Detecting frontal vehicle – Viola Jones Algorithm (OpenCV)
  - 3000 manually marked tail light objects for positive images
  - 3496 negative images
    - 3019 general images
    - 477 specific images (road scene without vehicle)

Samples of manually highlighted tail light objects

- Estimating Frontal Vehicle Distance
  - Apply detector on controlled data
  - Map the size of the detected tail light object to the distance





Detection Result and System Integration

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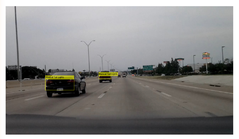
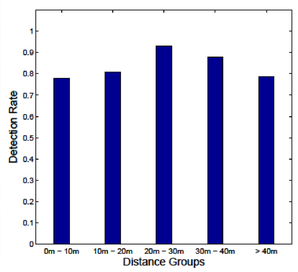
- Naturalistic Driving Data
- Distance approximated with the mapping
- 5 distance groups (< 10m, 10m-20m, 20m-30m, 30m-40m, >40m)
- Average detection rate is 83.2%

Detection Result



Manual Annotation

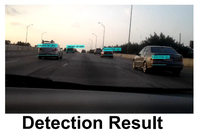


- Challenge: Blinking indicators

Detection Result

Manual Annotation

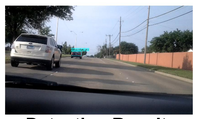
- Challenge: Adverse Illumination



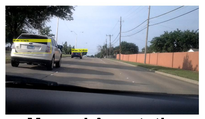
Detection Result

Manual Annotation

- Challenge: Similar appearance between tail light and the vehicle itself



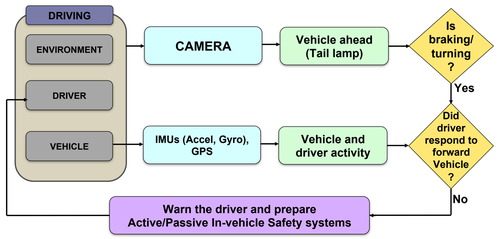
Detection Result

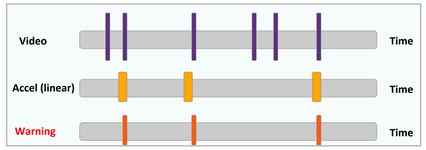


Manual Annotation

System Integration

- GPS estimates speed of ego-vehicle
- Accelerometer estimates the driver's intention to accelerate or decelerate





Conclusions & Future Work

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- Vehicle tail-light detector with high detection rate
  - 93.9% in controlled recordings
  - 83.2% in naturalistic recordings
- Frontal vehicle distance estimation using mapped object size
- IMUs and GPS sensors to estimate the vehicle dynamics using mobile device for rear-end collision prevention

Future Directions:

- Include more challenging conditions including night recordings
- Consider temporal information (tracking algorithms)
- Focus on detecting the front-vehicle actions (braking, turning, etc.)